

IN THE CLAIMS

Claims 1, 3, 4, 25, 27 and 28 have been amended, while claims 2 and 26 have been canceled. A complete listing of the claims, as amended, follows immediately hereinafter.

1. (currently amended) In an overall system in which a boring tool is moved through the ground within a given region along a path and in which region a cable is buried, a method comprising the steps of:

transmitting a boring tool locating signal from the boring tool such that the boring tool locating signal exhibits a forward locate point at the surface of the ground;

transmitting a cable locating signal from the cable such that the boring tool locating signal and the cable locating signal are distinguishable each from the other;

measuring intensities of the boring tool locating signal and the cable locating signal in a predetermined way using a locator;

establishing a pitch orientation of the boring tool; and

using the measured intensities and established pitch orientation, determining a positional relationship ~~to relative scale~~ including at least the forward locate point in scaled relation to the boring tool and the cable in said region.

2. (canceled) The method of claim 1 wherein said boring tool locating signal exhibits a forward locate point at the surface of the ground and wherein the positional relationship is determined including the forward locate point in scaled relation to the boring tool and the cable.

3. (currently amended) The method of claim 1 including the step of displaying the positional relationship including at least the boring tool and said cable.

4. (currently amended) The method of claim 3 ~~wherein said boring tool locating signal exhibits a forward locate point at the surface of the ground and~~ wherein the step of displaying the positional relationship includes the step of simultaneously displaying at least one distance between the boring tool and the forward locate point and another distance between the boring tool and the cable.

5. (original) The method of claim 3 wherein the display step includes the step of depicting a plan view illustrating the positional relationship to scale.

6. (original) The method of claim 3 wherein the display step includes the step of depicting an elevational view illustrating the positional relationship to scale.

7. (original) In an overall system in which a boring tool is moved through the ground within a given region along a path and in which region a cable is buried, a method comprising the steps of:

transmitting a boring tool locating signal from the boring tool which locating signal exhibits a forward locate point at the surface of the ground;

transmitting a cable locating signal from the cable such that the boring tool locating signal and the cable locating signal are distinguishable each from the other;

using a locator, finding the forward locate point;
 establishing a drilling direction extending through the forward locate point;
 moving the locator along a locating direction to a first point;
 at the first point, measuring a first set of intensities of the boring tool locating signal and the cable locating signal and establishing a reference angle as an angle δ defined between the drilling direction and the locating direction,
 moving the locator along the locating direction from the first point to a second point;
 at the second point, measuring a second set of intensities of the boring tool locating signal and the cable locating signal;
 establishing a pitch orientation of the boring tool; and
 using the measured first and second sets of intensities and the established pitch orientation, determining a positional relationship to relative scale including at least the boring tool and the cable in said region.

8. (original) The method of claim 7 wherein the positional relationship is defined within a horizontal xyz coordinate system having an origin defined at the location of the boring tool such that an xy plane is horizontal with an x axis coincident with the drilling direction while a z axis is orthogonal to the xy plane and an s coordinate system is defined having an origin coincident with the forward locate point and extending within the xy plane in said locating direction at the angle δ with respect to the drilling direction, and wherein the s coordinate of a point s_3 , having xyz coordinates x_3, y_3, z_3 directly above the cable and along said locating direction is determined by using the equations

$$\begin{aligned}
 \tan \gamma &= \frac{b_{v_1}}{b_{u_1}} \\
 s_1^2 &= (x_1 - x_{LP})^2 + y_1^2 \\
 s_2^2 &= (x_2 - x_{LP})^2 + y_2^2 \\
 s_3 &= s_1 + \frac{D_c}{\cos \gamma} \frac{b_{w1}}{b_{h1}} \\
 x_3 &= x_{LP} + s_3 \cos \delta \\
 y_3 &= s_3 \sin \delta \\
 \varepsilon &= 90^\circ + \gamma \\
 z_3 &= D_T
 \end{aligned}$$

where γ is an angle defined at the first point between the locating direction and a normal to the cable in the xy plane, b_{v_1} , b_{w_1} and b_{u_1} are components of the cable locating signal determined at the first point where b_{v_1} is an intensity component normal to the locating direction in the xy plane, b_{w_1} is an intensity component normal to the xy plane and b_{u_1} is an intensity component parallel to the locating direction in the xy plane, s_1 represents the s coordinate of the first point, s_2 represents the s coordinate of the second point, x_1, y_1 represents the xy coordinates of the first point, x_2, y_2 represents the xy coordinates of the second point, x_{LP} represents the x coordinate of the forward locate point, D_c is the depth of the cable and D_T is the depth of the boring tool.

9. (original) The method of claim 8 wherein the locating direction is generally coincident with the drilling direction in a plan view.

10. (original) The method of claim 7 wherein the locating direction is generally normal to the drilling direction in a plan view.

11. (original) The method of claim 7 including the step of selecting the locating direction as one of a first direction that is coincident with the drilling direction and a second direction that is normal to the drilling direction based on which of the first and second directions bisects the cable, in plan view, more closely approaching normal.

12. (original) The method of claim 7 wherein the locating direction is generally normal to the cable in plan view.

13. (original) The method of claim 12 wherein the cable locating signal includes a flux line orientation measured in a horizontal plane which is normal to the cable in plan view and the method includes the step of establishing the locating direction based on the flux line orientation measured in the horizontal plane.

14. (original) The method of claim 7 wherein the first and second points are to one side of said cable nearest the locator in a plan view.

15. (original) The method of claim 7 wherein the first and second points are on opposite sides of said cable with the second point nearest the locator in a plan view.

16. (original) The method of claim 7 wherein the forward locate point and the boring tool are on opposite sides of the cable in a plan view.

17. (original) The method of claim 7 wherein the first point is selected as the forward locate point.

18. (original) The method of claim 7 wherein the second point is selected as the forward locate point.

19. (original) The method of claim 7 wherein the step of determining the positional relationship includes the steps of

establishing a forward distance between the forward locate point and overhead point above the boring tool measured in a horizontal xy coordinate system,

measuring a depth of the boring tool in a selected way, and

determining a set of coordinate locations in the xy coordinate system for the first and second points based on the reference angle of the locating direction, the forward distance, established pitch of the boring tool, the depth of the boring tool, and the measured intensities of the boring tool locating signal and the cable locating signal at each of the first and second points.

20. (original) The method of claim 19 wherein the locator includes a magnetometer and wherein the step of establishing the reference angle of the locating direction includes the step of reading the reference angle using the magnetometer.

21. (original) The method of claim 19 wherein the step of determining the depth of the boring tool includes the steps of

with reference to a third point on the surface of the ground, measuring the intensity of the cable locating signal at a first height;

moving the locator to a second height where the first and second heights are vertically spaced apart with respect to one another vertically from the third point,

measuring the intensity of the cable locating signal at the second height, and

calculating the depth of the boring tool based on the intensity measurements at the first and second heights.

22. (original) The method of claim 21 wherein the third point is generally vertically above the cable.

23. (original) The method of claim 21 wherein the third point is horizontally displaced with respect to any point that is generally vertically above the cable.

24. (original) In an overall system in which a boring tool is moved through the ground within a given region along a path and in which region a cable is buried, said locating signal exhibiting a forward locate point at the surface of the ground, a method comprising the steps of:

transmitting a boring tool locating signal from the boring tool;

transmitting a cable locating signal from the cable such that the boring tool locating signal and the cable locating signal are distinguishable each from the other;

measuring intensities of the boring tool locating signal and the cable locating signal in a predetermined way using a locator;

establishing a pitch orientation of the boring tool; and

using the measured intensities and established pitch orientation, displaying a scaled positional relationship including at least the boring tool, the forward locate point and the cable in said region.

25. (currently amended) In an overall system in which a boring tool is moved through the ground within a given region along a path and in which region a cable is buried, a locating arrangement comprising:

a first arrangement for transmitting a boring tool locating signal from the boring tool such that said boring tool locating signal exhibits a forward locate point at the surface of the ground;

a second arrangement for transmitting a cable locating signal from the cable such that the boring tool locating signal and the cable locating signal are distinguishable each from the other; and

a locator for measuring intensities of the boring tool locating signal and the cable locating signal in a predetermined way and being configured for establishing a pitch orientation of the boring tool and for using the measured intensities and established pitch orientation to determine a positional relationship ~~to relative scale~~ including at least the forward locate point in scaled relation to the boring tool and the cable in said region.

26. (canceled) The locating arrangement of claim 25 wherein said boring tool locating signal exhibits a forward locate point at the surface of the ground and wherein the positional relationship is determined including the forward locate point in scaled relation to the boring tool and the cable.

27. (currently amended) The locating arrangement of claim 26 ~~25~~ wherein the locator includes a display arrangement for displaying the positional relationship to scale including at least the boring tool and the cable.

28. (currently amended) The locating arrangement of claim 27 ~~wherein said boring tool locating signal exhibits a forward locate point at the surface of the ground and~~ wherein the display arrangement is configured for simultaneous display of at least one distance between the boring tool and the forward locate point and another distance between the boring tool and the cable.

29. (original) The locating arrangement of claim 27 wherein said display arrangement is configured for depicting a plan view illustrating the positional relationship.

30. (original) The locating arrangement of claim 27 wherein the display arrangement is configured for depicting an elevational view illustrating the positional relationship.

31. (original) In an overall system in which a boring tool is moved through the ground within a given region along a path in a drilling direction and in which region a cable is buried, a locating arrangement comprising:

a first arrangement for transmitting a boring tool locating signal from the boring tool which locating signal exhibits a forward locate point at the surface of the ground in the drilling direction;

a second arrangement for transmitting a cable locating signal from the cable such that the boring tool locating signal and the cable locating signal are distinguishable each from the other;

a locator configured for (i) measuring intensities of the boring tool locating signal, (ii) finding the forward locate point, (iii) after having moved the locator in a locating direction from the forward locate point to a first point, measuring a first set of intensities of the boring tool locating signal and the cable locating signal, (iv) after moving the locator again in the locating direction from the first point to a second point, measuring a second set of intensities of the boring tool locating signal and the cable locating signal, (v) establishing a pitch orientation of the boring tool along with a reference angle δ that is defined between the drilling direction and the locating direction, and (vi) using the first and second sets of measured intensities, the established pitch orientation and the reference angle δ , determining a positional relationship to relative scale including at least the boring tool and the cable in said region.

32. (original) The locating arrangement of claim 31 wherein the positional relationship is defined within an xyz coordinate system having an origin defined at the location of the boring tool such that an xy plane is horizontal with an x axis coincident with the drilling direction while a z axis is orthogonal to the xy plane and an s coordinate system is defined having an origin coincident with the forward locate point and extending within the horizontal xy plane in said locating direction at the angle δ with respect to the drilling direction, and wherein the locator is configured for determining the s coordinate of a point s_3 , having coordinates x_3, y_3, z_3 directly above the cable and along said locating direction by solving the equations

$$\tan \gamma = \frac{b_{v_i}}{b_{u_i}}$$

$$\begin{aligned}
s_1^2 &= (x_1 - x_{LP})^2 + y_1^2 \\
s_2^2 &= (x_2 - x_{LP})^2 + y_2^2 \\
s_3 &= s_1 + \frac{D_c}{\cos \gamma} \frac{b_{w1}}{b_{h1}} \\
x_3 &= x_{LP} + s_3 \cos \delta \\
y_3 &= s_3 \sin \delta \\
z_3 &= D_T
\end{aligned}$$

where γ is an angle defined at the first point between the locating direction and a normal to the cable in the xy plane, b_{v_1} , b_{w_1} and b_{u_1} are components of the cable locating signal determined at the first point where b_{v_1} is an intensity component normal to the locating direction in the xy plane, b_{w_1} is an intensity component normal to the xy plane and b_{u_1} is an intensity component that is parallel to the locating direction in the xy plane, s_1 represents the s coordinate of the first point, s_2 represents the s coordinate of the second point, x_1, y_1 represents the xy coordinates of the first point, x_2, y_2 represents the xy coordinates of the second point, x_{LP} represents the x coordinate of the forward locate point, D_c is the depth of the cable and D_T is the depth of the boring tool.

33. (original) The locating arrangement of claim 31 wherein the locator is configured for determining the positional relationship based on the locating direction being selected as generally coincident with the drilling direction in a plan view.

34. (original) The locating arrangement of claim 31 wherein the locator is configured for determining the positional relationship based on the locating direction being selected as generally normal to the drilling direction in a plan view.

35. (original) The locating arrangement of claim 31 wherein the locator is configured for determining the positional relationship based on selecting the locating direction as one of a first direction that is coincident with the drilling direction and a second direction that is normal to the drilling direction where selection is based on which of the first and second directions bisects the cable, in plan view, more closely approaching normal.

36. (original) The locating arrangement of claim 31 wherein the locator is configured for determining the positional relationship based on the locating direction being selected as being generally normal to the cable in a plan view.

37. (original) The locating arrangement of claim 36 wherein the cable locating signal includes a flux line orientation measured in a horizontal plane which is normal to the cable in plan view and the locator is configured for establishing the locating direction based on the flux line orientation measured in the horizontal plane.

38. (original) The locating arrangement of claim 31 wherein the locator is configured for determining the positional relationship based on the first and second points being to one side of said cable nearest the locator in a plan view.

39. (original) The locating arrangement of claim 31 wherein the locator is configured for determining the positional relationship based on the forward locate point and the boring tool being on opposite sides of said cable in a plan view.

40. (original) The locating arrangement of claim 31 wherein the locator is configured for determining the positional relationship based on the first and second points being on opposite sides of said cable.

41. (original) The locating arrangement of claim 31 wherein the locator is configured for determining the positional relationship based on the first point being selected as the forward locate point.

42. (original) The locating arrangement of claim 31 wherein the locator is configured for determining the positional relationship based on the second point being selected as the forward locate point.

43. (original) The locating arrangement of claim 31 wherein the locator is further configured for determining a depth of the boring tool and for determining a set of coordinate locations for the first and second points using (i) the reference angle δ , (ii) a forward distance between the forward locate point and an overhead point above the boring tool measured in a horizontal xy coordinate system, (iii) the depth of the boring tool, (iv) the pitch of the boring tool and (v) the measured intensities of the boring tool locating signal and the cable locating signal at each of the first and second points.

44. (original) The locating arrangement of claim 43 wherein the locator includes a magnetometer for use in establishing the reference angle.

45. (original) The locating arrangement of claim 43 wherein the locator is configured for determining the depth of the boring tool using a first signal strength measured at a first operator determined distance generally vertically above a particular surface position on the ground and a second signal strength measured at a second operator determined distance generally vertically above said particular surface position and configured for determining a depth of the cable using the first and second signal strength measurements and the first and second operator determined distances.

46. (original) The locating arrangement of claim 45 wherein the locator is configured for using the first and second signal strengths measured generally vertically above the cable.

47. (original) The locating arrangement of claim 45 wherein the locator is configured for using the first and second signal strengths as measured horizontally displaced from any point on the surface of the ground which is vertically above the cable.